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MUNICIPAL ELECTRIC LIGHTING IN CHICAGO.

THE electric-light plant operated by the City of Chicago had its origin in an attempt to mitigate the "bridge nuisance." Ex-Mayor John A. Roche, in a letter dated June 3, 1887, proposed to the city council the establishment of an electric-light plant for the purpose of lighting the river from Halsted Street to the lake by arc lamps, in order that the bridges might be kept closed during the day, and be opened for the ingress and egress of vessels only from midnight to six A.M. In accordance with this suggestion, the city council, after due consideration, ordered the necessary steps for such purpose, and a plant operating 105 arc lamps, placed along the river according to the instructions contained in the ordinance, was installed at the corner of Washington and Clinton streets, on December 24, 1887.

While the project of lighting the river was still under consideration, the extension of the system was proposed. Out of this proposal and the discussion which followed grew an order, passed October 24, 1887,

that the superintendent of the fire alarm telegraph prepare and submit to the city council within two months an estimate of the cost to the city for procuring the necessary plant and supplying electric lighting by the year for the streets and population between the lake, Halsted Street, Chicago Avenue and Twelfth Street.

The idea indicated in this order has been gradually put into practice so far as the lighting of the streets is concerned, but the city has not yet undertaken to supply light to private consumers. The gradual extension of the system may be seen from the numbers of lamps operated in successive years: 1887, 105; 1888, 297; 1889, 669; 1890, 929; 1891, —; 1892, 1027; 1893, 1110.

At the close of the year 1893, Superintendent John W. Barrett made a detailed analysis of the expenditures during

the year in operating the 1110 arc lamps which were maintained by the city. Mr. Barrett is in charge of the city telegraph connected with the fire department of the city, and by virtue of that fact exercises a general superintendence over the city's electric-light plant. His analysis, an abstract and *résumé* of which is published in connection with his report to the fire marshal of the city for the year 1893, is concerned only with the money outlay of the department, and fails to take into account the various items of superintendence and office expense, water expense, interest, taxes, insurance and depreciation. Concerning the last item Mr. Barrett writes, in a letter addressed, under date of June 5, 1894, to Major H. Elliot, Colonel of Engineers, U.S.A., Washington, D.C.:

In regard to depreciation I beg leave to state that in a city like this it is extremely difficult to arrive at any fair percentage which should be charged up for depreciation. As one example why it is difficult, I refer you to page 151 of the report [of the fire marshal for 1893], where you will find that we disposed of a building, engines, dynamos and other apparatus at cost price (after they had been in service several years), and the land on which they were located at about twenty-five per cent more than its cost price.

We *must* keep all of our apparatus in good working order, so that it is practically as good as new; so taking everything into consideration, we do not allow anything for depreciation.

What is said in this extract about the sale of apparatus at cost price is true enough, but it is somewhat disingenuous; for the plant there spoken of was condemned at the instance of the Metropolitan Elevated Railway Company of Chicago, and sold to them for the purpose of completing their right of way. It is evident that the consideration received from such a sale offers no very sure index to actual value. When it is borne in mind that dynamos of the best patterns known ten years ago are to-day worth little more than their value as old iron, and that within the last four years there has been a fall of at least twenty or twenty-five per cent in the price of such apparatus, it is evident that some allowance should be made for depreciation. Competent engineers and managers of electric

apparatus — men acquainted with both the sale and the management of dynamo-electric machinery and with electric lighting — agree that the minimum depreciation ought to be estimated at ten per cent per annum, and that for steam-generating apparatus and engines the allowance for depreciation should be at least five per cent per annum.

It is the purpose of this paper to make allowance for the various neglected items before-mentioned, and thus to get an estimate of the cost to the city of its electric lighting under municipal management, in a proper form for comparison with the cost under private management.

The expenditure for coal at the four power-stations operated during 1893 was \$28,509.87, or a monthly average of \$2,375.82. The coal used ranged in price from \$3.50 per ton for Hocking Valley nut to \$1.65 per ton for Indiana block screenings. Estimating the average value at \$2.50 per ton, and the evaporating power at seven pounds of water per pound of coal, the average monthly consumption of water would be 1,592 M gallons approximately. The city charges for water supplied in such quantities 10 cents per M for the first 165 M gallons and 8 cents per M for all used after the first 165 M. At this rate the value of the water evaporated by \$2,375.82 worth of coal at \$2.50 per ton, is \$130.65, or five and one-half per cent of the value of the coal. At this rate the allowance for water consumed during the year should be \$1,567.92, or an average of \$1.41 $\frac{682}{1110}$ per lamp per year.

The value of the plant, as given in the letter to Major Elliot before referred to, was, on December 31, 1893, \$688,312.80. At about the beginning of the construction of this plant the credit of the city was such that a large issue of 3 $\frac{1}{2}$ per cent bonds was sold at 102 $\frac{78}{100}$. Assuming that a smaller 3 $\frac{1}{2}$ per cent issue of, say, the value of the plant, might have been floated at par, the allowance per annum for interest should be \$24,090.95, or an average charge per lamp of \$21.70 $\frac{395}{1110}$ per annum.

The aggregate of city, county and state taxes levied in Chicago amounts to nearly eight per cent per annum of the

assessed value. The assessed value is estimated to be about one-tenth of the market value. Estimating the taxes, then, at three-quarters of one per cent of value, the tax charge on the electric light plant for 1893 would have been \$5,162.35, or an average per lamp of \$4.65 $\frac{0.85}{1110}$.

The value of housed property, as given at the close of 1892 in the comptroller's report for that year, was :

Buildings	\$66,987.13
Steam plant and tools	95,518.79
DYNAMOS	58,075.00
Supplies on hand (1893)	8,840.40
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Total	\$229,421.32

Estimating fire insurance premium on this at one and one-half per cent on half valuation, an allowance of \$1,720.66 should be made for insurance, or \$1.55 $\frac{0.16}{1110}$ per lamp per year.

The depreciation on \$95,518.79 worth of steam plant and tools at five per cent per annum would be \$4,775.94, or an average of \$4.30 $\frac{2.94}{1110}$ per lamp per year. The electric plant included the following items :

DYNAMOS (1892 invt.)	\$58,075.00
LAMPS (1893 invt.)	41,241.77
Underground circuit (1893 invt.) . . .	164,495.20
Conduit system (1893 invt.)	152,552.91
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Total	\$416,364.88

At ten per cent per annum, depreciation would be \$41,636.49, an average of \$37.51 $\frac{0.89}{1110}$ per lamp per annum.

To Mr. Barrett's reported expenditure of \$96.64 $\frac{7.53}{1110}$ per lamp per annum there should then be added the following items :

Water	\$1.41 $\frac{6.82}{1110}$
Interest	21.70 $\frac{3.95}{1110}$
Taxes	4.65 $\frac{0.85}{1110}$
Insurance	1.55 $\frac{0.16}{1110}$
Depreciation of steam plant, <i>etc.</i>	4.30 $\frac{2.94}{1110}$
" " electric plant	37.51 $\frac{0.89}{1110}$

The total is $\$167.78\frac{044}{1110}$, which is nearly the proper amount for comparison with the cost of electric light furnished by private companies. This amount ought to be increased by the average expenditure per lamp per year for book-keeping and other office expenses, and diminished by the average increase in valuation of real estate per lamp per year, and the accrued interest on the allowances for depreciation. As the allowance for depreciation per lamp per year in this computation is $\$41.82$, the interest on it ought nearly to balance the office expenses, and our total expense of $\$167.78$ would then have to be reduced only by the average increase in the value of real estate per lamp. As no satisfactory means of determining this is at hand, it is impossible to say just what allowance should be made; it could hardly be more than $\$2.78$ per lamp per year, however, so that we may quite safely conclude that the total expense to the city for each lamp it operated in 1893 was at least $\$165.00$.

For arc lamps rented of various lighting companies of the city $\$175$ per lamp per year was paid in 1892, and $\$137.50$ per lamp per year in 1893. The estimated cost to the city of the lamps operated by the city plant in 1892 was given in the comptroller's report for that year as $\$102.50$; this presumably was obtained in a manner similar to that by which the estimate of $\$96.65$ was obtained in 1893. As the plant operated in 1892 was nearly as valuable as that operated in 1893, and the number of lamps (1,027) somewhat less, the actual expense in 1892 must have been rather more than $\$171$ per lamp. It is thus extremely doubtful that the city has saved any money by operating a plant of its own prior to 1893, and it seems very probable that the expense of operation in 1893 considerably exceeded the amount paid for hired lamps.

This, however, is not saying that the experience of the City of Chicago goes to show that the municipal operation of electric light plants is necessarily uneconomical. It is impossible to say just what influence the fact that the city owns and operates an electric-light plant has had upon the rates demanded by private companies for city lighting; and further than this, the

full utilization of the city plant would materially reduce the expense per lamp operated.

To estimate the reduction in the expense per lamp secured by the full utilization of the plant, I have proceeded thus: The aggregate horse-power of the steam engines used in the various plants in 1893 was as follows:

Plant No. 1	500
No. 4	425
No. 6	625
No. 8	375

The number of lamps operated from these various plants was:

No. 1	350
No. 4	307
No. 6	354
No. 8	99

The expenditures at these various plants were, including computed value of water consumed (computation being effected by adding five and one-half per cent of the value of the coal consumed):

No. 1	\$33,636.67
No. 4	27,676.28
No. 6	34,227.01
No. 8	13,305.89

Assuming that these expenditures may each be divided into two portions, one of which is proportional to the capacity of the plant, the other to the number of lamps operated, the first being represented by $\$a$ per lamp, and the second by $\$b$ per lamp; and assuming further that we may take the lamp capacity equal in number to the horse-power capacity, we have, taking approximate values of expenditures, $\$(500a + 350b - 33637)$ as the error for given values of a and b in the case of the first plant. Now, making use of the rule of least squares, we have that those values of a and b are to be preferred, which make

$(500a + 350b - 33637)^2 + (425a + 307b - 27676)^2$
 $+(625a + 354b - 34227)^2 + (375a + 99b - 13306)^2 [= \phi(a, b)]$
 a minimum. In order that $\phi(a, b)$ may be a minimum, $\frac{d\phi}{da}$ must = 0, and $\frac{d\phi}{db}$ must = 0.

$$\frac{d\phi}{da} = 1,923,750a + 1,127,700b - 109,924,850.$$

$$\frac{d\phi}{db} = 1,127,700b + 703,732b - 67,406,268.$$

Putting $\frac{d\phi}{da} = 0$, and $\frac{d\phi}{db} = 0$, and solving for a and b , we get

$a = 16.365686+$, and $b = 69.581953+$, thus making a total cost per lamp per annum of \$85.95 when plant is fully utilized, and only water expense is included besides those items taken into account by Mr. Barrett. These empirical values, when applied to the case of 1893, give a total expense of \$105.97, too small by an average of a trifle less than 9½ cents per lamp. If the result \$85.95 be increased by 10 cents, we shall then have \$86.05 as the cost per lamp per annum, exclusive of interest, taxes, insurance, depreciation, office expense, change in value of real estate and interest on depreciation allowance.

To secure this complete utilization, I have estimated that the plant would have to be increased as follows :

810 posts, hoods, &c., @ \$55.00 . . .	\$44,550.00
100-light dynamo, ¹ " \$22.91½ . . .	2,291.66
700 lamps, ¹ " \$27.9793 . . .	19,585.53
Total	\$66,427.19

This would involve the following increased charges :

Interest on \$66,427.19, @ 3½% per annum . .	\$2,324.96
Taxes " " " ¾ of 1% per annum	498.20
Depreciation on \$21,877.19, @ 10% per annum . .	\$2,187.72
Insurance on \$2,291.66, @ ¾ of 1% per annum . .	17.19
Total	\$5,028.07

¹ Prices at which the Western Electric Co. recently contracted to supply Detroit.

The previous total estimate for interest, taxes, insurance and depreciation, \$77,386.39, being increased by \$5,028.07, gives \$82,414.46, the total estimated allowance for these items in case the plant were to be fully utilized. This sum divided by 1,925 gives \$42.813 per lamp per year; \$86.05 increased by \$42.81 gives \$128.86—a value probably very close to the expense per lamp per year if the city plant were to be fully utilized. This, in comparison with \$167.78, shows the saving that is to be effected by fully utilizing the plant.

Disinterested electricians and engineers with whom I have talked seem to be of the opinion that the plant is efficiently managed. Business principles seem to be observed in the maintenance of the *personnel* of the force, and although there is some slight reason to think that the finger of the alderman can occasionally be seen in the appointment of the less skilled workers, such as firemen, linemen and laborers, I have not heard it asserted that the efficiency of the force is thereby impaired, or that inefficient men are retained on account of the manner of their appointment.

The only questionable part of the management so far discovered is the practice of inventorying all property at cost price, thus omitting all consideration of depreciation in efficiency of apparatus and further depreciation of value on account of fall in price, and presenting the appearance of greater wealth on the part of the city than it actually possesses.

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